Convergence to attractors in the climate system

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The time evolution of the climate system is unpredictable. The inherent unpredictability originates from the irregular, chaotic nature of the solutions of the underlying dynamics. In such circumstances only probabilistic predictions can be made, and we point out that the full range of possible outcomes (called the internal variability of the climate) is described by the so-called natural distribution on a dynamical attractor. This is due to the fact that any initial probability distribution converges to the natural one with an exponential speed. We emphasize that this distribution exists, beyond what a traditional framework covers, in non-periodically time-dependent dynamical systems as well, so that this approach is applicable even if a parameter (like the greenhouse gas concentration) is shifting. In this case the natural distribution itself depends on time, and this dependence (especially shifts in expectation values) represents climate change. Numerically, the natural distribution can be represented by an ensemble of trajectories, but only after convergence has took place. Then the statistical characteristics (like expectation values or standard deviations) are to be evaluated with respect to the ensemble.